CHEVRON FILM COOLED WALL

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BACKGROUND OF THE INVENTION

The present invention relates generally to gas turbine engines, and, more specifically, to film cooling therein.

In a gas turbine engine air is pressurized in a compressor and mixed with fuel in a combustor for generating hot combustion gases. Energy is extracted from the gases in a high pressure turbine (HPT) which powers the compressor, and in a low pressure turbine (LPT) which powers a fan in a turbofan aircraft engine application, or powers an external shaft for marine and industrial applications.

Engine efficiency increases with temperature of combustion gases, but the combustion gases heat the various components along their flowpath, which in turn requires cooling thereof for obtaining a long life of the engine. The flowpath components subject to the hot combustion gases are cooled by bleeding air from the compressor which correspondingly reduces engine efficiency since the bled air is not used in the combustion process.

Accordingly, gas turbine engine cooling art is mature and includes innumerable patents for minute differences in cooling circuits and features in the various components of the hot flowpath.

For example, the combustor includes radially outer and inner liners which require cooling during operation. Turbine nozzles include hollow vanes supported between outer aid inner bands which also require cooling. Turbine rotor blades are hollow and typically include cooling circuits therein, with the blades being surrounded by turbine shrouds which also require cooling. The hot combustion gases are discharged through an exhaust which may also be lined, and suitably cooled.

In all of these exemplary gas turbine engine components, thin metal walls of high strength superalloy metals are typically used for enhanced durability while minimizing the need for cooling thereof. Various cooling circuits and features are tailored for these individual components in their corresponding environments in the engine, but all these components typically include common rows of film cooling holes.

A typical film cooling hole is a cylindrical bore inclined at a shallow angle through the heated wall for discharging a film of cooling air along the external surface of the wall to provide thermal insulation against the hot combustion gases which flow thereover during operation. The film is discharged at a shallow angle over the wall outer surface to minimize the likelihood of undesirable blow-off thereof which would lead to flow separation and a loss of the film cooling effectiveness.

Furthermore, the film cooling holes are typically arranged in rows of closely spaced apart holes which collectively provide a large area cooling air blanket over the external surface.

However, the more holes required for providing full-surface coverage of the film cooling boundary layer, the more air is also required which therefore decreases engine efficiency.

Accordingly, the art of film cooling holes itself is replete with numerous patents on the minute details of various forms of those holes for improving their efficiency for maintaining flow attachment with the widest possible lateral

dispersion. For example, the discharge end of the simple cylindrical film cooling bore may diverge to the outer surface of the wall being cooled for diffusing the pressurized cooling air as it is discharged from the outlet. Diffusion is an aerodynamic mechanism in which the high velocity of the pressurized cooling air is reduced which in turn increases its pressure.

Diffusion outlets for typical film cooling holes decrease the discharge velocity thereof for ensuring good flow attachment or the discharged film cooling air without undesirable flow separation. And, the lateral width of the diffusion outlet correspondingly increases the lateral flow coverage of the film.

However, diffusion in film cooling holes has a typical limit due to the diverging half-angle of the diffusion outlet to prevent undesirable flow separation. For example, the diffusion angle is typically limited to about ten degrees on each side of the diffusion outlet to prevent overexpansion of the discharge cooling air which could lead to undesirable film separation.

Accordingly, it is desired to provide an improved film cooling hole having increased film coverage while maintaining good flow attachment of the discharged film cooling air.

BRIEF DESCRIPTION OF THE INVENTION

A wall in a gas turbine engine includes inner and outer surfaces having a row of compound chevron film cooling holes extending therethrough. The chevron holes diverge both longitudinally and laterally between an inlet at the wall inner surface and a chevron outlet at the wall outer surface.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, in accordance with preferred and exemplary embodiments, together with further objects and advantages thereof, is more particularly described in the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a schematic representation of an exemplary gas turbine engine having various components each including a heated wall cooled by a row of compound chevron film cooling holes in accordance with an exemplary embodiment.

FIG. **2** is a transverse sectional view through one of the chevron holes illustrated in FIG. **1** and taken along line **2-2**.

FIG. **3** is a plan view of the inclined chevron hole illustrated in FIG. **2** and taken along line **3-3**.

FIG. **4** is a lateral sectional view through the chevron outlet illustrated in FIG. **3** and taken along line **44**.

FIG. **5** is a schematic representation of an electrical discharge machining (EDM) electrode used for forming the chevron hole illustrated in FIGS. **1-4**.

FIG. **6** is a plan view, like FIG. **3**, of a row of chevron holes in accordance with another embodiment.

FIG. **7** is a transverse sectional view through the chevron outlet illustrated in FIG. **6** and taken along line **7-7**.

FIG. **8** is a schematic view, like FIG. **5**, of an EDM electrode for forming the chevron hole illustrated in FIGS. **6** and **7**.

FIG. **9** is plan view, like FIG. **3**, of a chevron hole in accordance with another embodiment.

FIG. **10** is a lateral sectional view, like FIG. **4**, of the chevron outlet illustrated in FIG. **9** and taken along line **10-10**.